Impact of seed-row placed conventional and controlled release P fertilizer with K on emergence, yield and P uptake of various crops under controlled environment conditions.

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Introduction

A previous study (Qian et al. 2006) showed that controlled-release P fertilizer (CRP) placed in the seed row had no negative impact on the emergence of the majority of nine crops tested, even at rates up to 80-100 kg P_2O_5 ha^{-1}, while conventional monoammonium phosphate fertilizer (MAP) resulted in general decreased emergence beginning at rates between 20 and 40 kg P_2O_5 ha^{-1}, depending on the crop. As potassium fertilizer is also becoming more commonly used on the prairies as a starter nutrient along with P, examining the impact of combinations of starter P and K in the seed-row on crop emergence, yield and uptake is useful for refining guidelines for seed-row placed P and K fertilizers.

Objectives

To examine the effect of KCl added at 20 kg K_2O ha^{-1} (a typical starter seed-row placed K rate for prairies) together with two P fertilizer sources, MAP and CRP (Agrium Inc.) on seedling emergence, yield and P uptake of eleven prairie crops.

Materials and Methods

Soil: Haverhill loam (Table 1).

Table 1. Some characteristics of Brown Chernozemic soil used for the study.

Soil	pH	EC	Texture	Organic C	Avail. P*	Avail. N**	Avail. K*
		mS cm^{-1}		g kg^{-1}	----------	kg ha^{-1}	----------
Haverhill	7.7	1.0	loamy	19.9	18.0	44.0	1178

*measured by modified Kelowna
** sum of NH_4-N and NO_3-N

Crops and Seed Rates: (Table 2)

Table 2. The crops utilized in the study and seeding rates used*

Crop	Variety	Seed Rate kg ha^{-1}
Wheat	Prodigy	112
Argentine Canola OP non HT	Sprint	12
Yellow pea	Carneval	410
Flax	CDC Vimy	35
Canary seed	Common Itchless	40
Oriental Mustard	Cutlass	11
Kabuli Chickpea	Xena	1450
Pinto Bean	Pintium	940
Alfalfa	Beaver	10
Bromegrass	Knowles	40
Oat	Triple Crown	134

*Certain crops were seeded at higher rates than would normally be used in the field so as to ensure sufficient seedlings were present in each treatment.

Fertilizer:

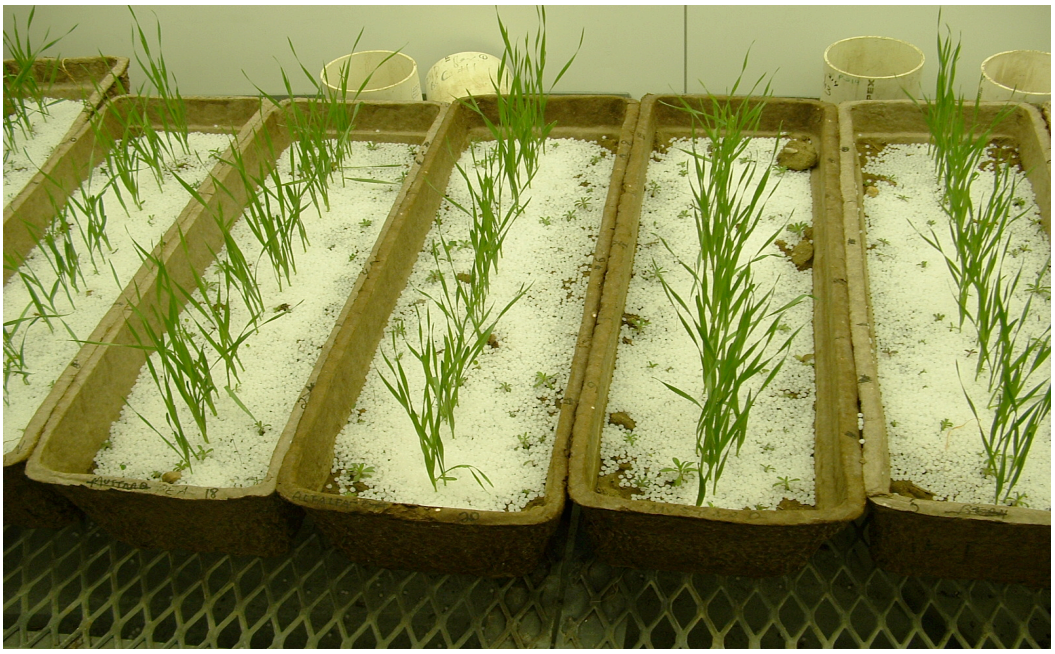
- Source -
  - Conventional mono-ammonium phosphate (MAP) - $NH_4H_2PO_4$ (12-51-0)
  - Controlled released MAP (CRP) - $NH_4H_2PO_4$ coated to control fertilizer release rate (Agrium Inc.)
- Rate –
  - P - 0, 20, 30, 40, 60, 80 and 100 kg P_2O_5 ha^{-1}
  - K - 20 kg K_2O ha^{-1} as KCl (0-0-60 potash)
  -

Laboratory Study:

- Tray: mixed soil in a tray (60cm long and 40cm wide and 5cm deep) for twelve treatments.
- Replication: four.
- Growth period: two weeks.
- Seeding tool: knife opener with a 15% seed bed utilization and on-row packing.
- Moisture: near field capacity after seeding and fertilization, and then watering daily.
- Temperature: 20°C.
- Light: ON all the time.
- Emergence counting: started from day 5 after seeding.

Growth Chamber Study:

- Flat: mixed soil in a flat (100 cm long & 15 cm wide and 15 cm deep) for three treatments.
- Replication: four.
- Growth period: four weeks.
- Moisture: field capacity initially, then watering once every 2 days to simulate rainfall.
- Temperature: 24^{o}C daytime & 15^{o}C at night.
- Light: 18 hr day length and 6 hr night period.
- Emergence counting: started from day 5 after seeding.
- Harvest: Above ground biomass harvested, crushed & ground for yield & P uptake analysis.



Results and Discussion

Effect of P Fertilizer rate on Emergence Counts

Yellow pea was the most sensitive to seed-row P placement as a negative impact over the range of rates examined was observed at rate of 20 kg P_2O_5 ha^{-1} or above, followed by flax, and mustard with the negative impact observed at rates above 20 kg P_2O_5 ha^{-1} (Tables 4 and 5). Canola, canary seed, and alfalfa were less sensitive to seed-row P placement, with a negative impact occurring mainly at rates around 40 kg P_2O_5 ha^{-1} and above (Tables 3 and 4), followed by bromegrass, chickpea, pinto bean, oat and wheat. Negative impact for these crops was occurring at the rates between 60 and 80 kg P_2O_5 ha^{-1}.

Table 3. Percentage of seeds planted that emerged over 2 weeks as affected by different rates of conventional MAP fertilizer with or without 20 kg K_2O ha^{-1} potash for wheat, canola, canary seed and bromegrass

Fert. rate	Wheat		Canola		Canary		Bromegrass	
kg P_2O_5 ha^{-1}	P only	With K	P only	With K	P only	With K	P only	With K
0	93a	91a	95a	89a	83a	63a	69a	61a
10	95a	91a	98a	86a	79a	61a	62a	59ab
20	91a	89ab	95a	82a	79a	69a	59ab	55ab
30	89ab	86ab	91a	80a	73ab	58ab	58ab	57ab
40	91a	86ab	73b	75a	68bc	56ab	57ab	57ab
60	80b	82b	48c	59b	59c	46b	50b	52b
80	64c	68c	43c	45bc	53cd	33c	26c	25c
100	52d	59d	36c	43c	38d	30c	23c	17c

Means in columns followed by a different letter are significantly different at $p < 0.05$.

When combining 20 kg K_2O ha^{-1} with P in the seed row, generally there was little influence observed on germination and emergence with the exception of canary seed and canola (Table 3, 4 and 5). These two crops appeared more sensitive to the addition of the K than other crops (Table 4 and 5).

Table 4. Percentage of seeds planted that emerged over 2 weeks as affected by different rates of conventional MAP fertilizer with or without 20 kg K_2O ha^{-1} potash for mustard, yellow pea, pinto bean and alfalfa

Fert. rate	Mustard		Yellow pea		Pinto bean		Alfalfa	
kg P_2O_5 ha^{-1}	P only	With K	P only	With K	P only	With K	P only	With K
0	70a	64ab	75a	75a	89a	89a	72a	72a
10	63ab	66a	61ab	68ab	93a	86a	69a	74a
20	66ab	55abc	43bc	54bc	89a	82ab	67a	69ab
30	55b	50bc	32c	39cd	86a	82ab	71a	64abc
40	41c	46cd	14d	25de	89a	79ab	46b	57bc
60	38cd	32de	7de	18e	75a	71b	44b	53c
80	34cd	29e	0e	11e	50b	46c	39bc	24d
100	27d	18e	0e	11e	29c	32c	29c	18d

Means in columns followed by a different letter are significantly different at $p < 0.05$.

Table 5. Percentage of seeds planted that emerged over 2 weeks as affected by different rates of conventional MAP fertilizer with or without 20 kg K_2O ha^{-1} potash for flax, chickpea and oat

Fert. rate	Flax		Chickpea		Oat	
kg P_2O_5 ha^{-1}	P only	With K	P only	With K	P only	With K
0	67ab	65a	89a	86a	92a	89a
10	69a	63ab	79ab	82a	89a	86ab
20	65ab	63ab	93a	86a	89a	86ab
30	54bc	54b	75ab	75a	86a	83ab
40	42cd	43c	75ab	71a	81a	81ab
60	33de	35cd	68bc	68a	78a	75b
80	22e	31de	36d	36b	61b	58c
100	21e	22e	50cd	46b	58b	50c

Means in columns followed by a different letter are significantly different at $p < 0.05$.

The high sensitivity of yellow peas and flax to seed placed P has been documented previously. In comparison to conventional MAP (Tables 3, 4 and 5), the controlled-released CRP fertilizer product showed no negative impact on emergence even at rates up to 80-100 kg P_2O_5 ha^{-1} (Tables 6, 7 and 8) with the exception of bromegrass where decrease in the emergence counts was observed at the 80 kg P_2O_5 ha^{-1} together with 20 kg K_2O ha^{-1} (Table 6).

Table 6. Percentage of seeds planted that emerged over 2 weeks as affected by different rates of CRP fertilizer with or without 20 kg K_2O ha^{-1} potash for wheat, canola, canary seed and bromegrass

Fert. rate	Wheat		Canola		Canary		Bromegrass	
kg P_2O_5 ha^{-1}	P only	With K	P only	With K	P only	With K	P only	With K
0	93a	91a	95a	89a	81a	63a	69a	61a
10	93a	91a	95a	86a	80a	63a	66a	59ab
20	95a	93a	93a	80a	83a	63a	69a	58ab
30	93a	91a	86a	82a	78a	61a	62a	54abc
40	89a	93a	91a	80a	75a	56a	60a	56ab
60	89a	91a	86a	80a	73a	63a	66a	53abc
80	91a	91a	91a	80a	75a	58a	56a	46bc
100	91a	91a	84a	80a	74a	51a	58a	42c

Means in columns followed by a different letter are significantly different at $p < 0.05$.

The absence of a significant negative impact of seed placed CRP for these crops for rates up to 80 – 100 kg P_2O_5 ha^{-1}, implies much improved crop safety for controlled-release P fertilizer compared to conventional P fertilizer. A reduced salt-effect/damage potential from a CRP product would be of benefit in potentially allowing higher rates to be safely placed and a greater of quantity of other nutrients to be seed-row placed along with phosphorus in single shoot systems.

Table 7. Percentage of seeds planted that emerged over 2 weeks as affected by different rates of CRP fertilizer with or without 20 kg K_2O ha^{-1} potash for mustard, yellow pea, pinto bean and alfalfa

Fert. rate	Mustard		Yellow pea		Pinto bean		Alfalfa	
kg P_2O_5 ha^{-1}	P only	With K	P only	With K	P only	With K	P only	With K
0	70a	64a	75a	75a	89ab	89a	72a	72a
10	68a	68a	79a	71a	96a	89a	71a	78a
20	70a	66a	79a	75a	93ab	89a	72a	79a
30	73a	66a	82a	68a	93ab	86a	67a	74a
40	70a	64a	75a	71a	100a	86a	67a	75a
60	71a	68a	79a	64a	93ab	89a	72a	72a
80	68a	64a	75a	68a	79b	82a	71a	69a
100	66a	61a	86a	68a	93ab	86a	71a	69a

Means in columns followed by a different letter are significantly different at $p < 0.05$.

Table 8. Percentage of seeds planted that emerged over 2 weeks as affected by different rates of CRP fertilizer with or without 20 kg K_2O ha^{-1} potash for flax, chickpea and oat

Fert. rate	Flax		Chickpea		Oat	
kg P_2O_5 ha^{-1}	P only	With K	P only	With K	P only	With K
0	67a	65a	89a	86a	92a	89a
10	68a	69a	89a	86a	92a	83a
20	69a	65a	86a	89a	89a	86a
30	72a	64a	93a	82a	89a	75a
40	69a	68a	89a	86a	89a	89a
60	71a	64a	86a	79a	79b	86a
80	65a	63a	93a	82a	86ab	83a
100	65a	64a	93a	82a	81b	81a

Means in columns followed by a different letter are significantly different at $p < 0.05$.

Effect of P Fertilizer Rate and Form on Dry Matter Yield and P Uptake

Good yield response and P uptake increase (first 4 wks) was achieved up to the point where injury was observed in the canola for MAP treatments (Tables 9 and 10). As no injury occurred when CRP was used, yield and P uptake in canola was the highest at the highest rate of P addition (40 kg P_2O_5 ha^{-1}).

Table 9. Dry matter yield (g/50cm seed-row) & P uptake (mg/50cm seed-row) measured after 4 wks as affected by different P fertilizers with potash for wheat and canola (2005).

Fertilizer	Wheat				Canola			
rates	Yield		P Uptake		Yield		P Uptake	
kg P_2O_5 ha^{-1}	MAP	CRP	MAP	CRP	MAP	CRP	MAP	CRP
0	0.79c	0.79d	2.89d	2.89d	0.86c	0.86b	3.80e	3.80c
10	1.09bc	0.88cd	4.11c	3.83c	1.04bc	0.90ab	5.85d	5.18b
20	1.19ab	0.99bc	5.15b	4.61bc	1.13ab	0.96ab	7.05bc	5.83b
30	1.31a	1.13ab	6.53a	6.51a	1.33a	1.13a	8.83a	7.68a
40	1.31a	1.21a	6.38a	7.23a	0.90c	1.13a	5.97cd	7.78a

Values in a column followed by the same letter are not significantly different at $p<0.05$.

Generally there were few significant differences between two forms of P fertilizer on the yield and P uptake at rates below the damage threshold. The benefit of using CRP fertilizer due to its less harmful effect on seed germination and emergence is evident at higher rates. Addition of 20 kg K_2O ha^{-1} had little impact on crop yield and P uptake, as would be anticipated given the high extractable K in this soil (Table 1).

Table 10. Dry matter yield (g/50cm seed-row) & P uptake (mg/50cm seed-row) measured 4 wks as affected by different P fertilizers with potash for wheat and canola (2006).

Fertilizer	Wheat				Canola			
rates	Yield		P Uptake		Yield		Uptake	
kg P_2O_5 ha^{-1}	MAP	CRP	MAP	CRP	MAP	CRP	MAP	CRP
0	0.72e	0.72bc	2.09c	2.09d	1.25c	1.25b	5.17d	5.17c
10	0.77bc	0.66c	2.44c	2.01d	1.64ab	1.48b	7.24c	6.94b
20	0.89ab	0.72b	3.03b	2.56c	1.81a	1.51b	9.23ab	8.27b
30	0.88ab	0.87ab	3.63a	3.28b	1.80a	1.95a	9.50a	11.04a
40	1.03a	0.92a	4.11a	3.71a	1.48b	1.80a	8.07bc	10.93a

Values in a column followed by the same letter are not significantly different at $p<0.05$.

Conclusion

No negative impact on seed germination and emergence was observed for most of crops tested with seed-placed MAP, with or without 20 kg K_2O ha^{-1} potash addition, at rates up to ~20 to 30 kg P_2O_5 ha^{-1}. Yellow pea, flax, and mustard tended to be most sensitive to seed-placed MAP. The CRP formulation resulted in greatly increased tolerance of crops to high rates of seed-placed P. No significant injury occurred for most crops until rates of 80 kg P_2O_5 ha^{-1}or above.

Addition of 20 K_2O ha^{-1} starter K in the seed-row with the P fertilizer generally did not lead to harmful effects on germination and emergence for most crops, but some additional injury potential was evident with crops that appeared more sensitive to seed placed K, especially at high rates.

Large differences in P availability as revealed in crop yield and P uptake were not evident between the MAP and CRP forms, and between treatments with and without adding starter K.
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References

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